Spatial awareness:

State of the art and future needs of spatial audio journalism

A summary of the findings of the Spatial Audio Journalism project, 2019-2020, Falmouth University and University of Brighton.

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A note about terms:

There's a lack of agreement about the use of some key terms in this area, so just for clarity, we are using **journalism** to refer to factual narrative content broadly - documentaries and features and investigative podcasts - not only news reporting. **Journalists** then are people who make this factual content, but we do also use other terms like producer and programme-maker.

We choose to call this kind of audio **immersive** and **spatial**, because they're easily recognised generic terms that include various technical formats. However, as we explain below, not everyone likes these terms.

Contents

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Executive summary

Rationale for this research:

The best audio journalism is already utterly engrossing and immersive but tools to deliver a vivid sensation of three-dimensional space are increasingly available. Many believe in their potential to capture listeners' attention where traditional media cannot, enabling listeners to understand and empathise with other people's lives and their experiences of the stories in the news (de la Peña et al., 2010; de la Peña, 2016; Elmezeny, Edenhofer, & Wimmer, 2018; Van Damme, All, De Marez, & Van Leuven, 2019).

Immersion is associated with the predominantly visual Virtual Reality, but immersive audio has been experiencing a quiet but sustained period of uptake and development in recent years too. It is used in cinema and gaming (Melchior, Churnside, & Spors, 2012) and in VR and 360 video, which have also raised awareness of immersion among speech programme makers. There are relatively cheap and accessible tools to record and edit, with binaural being especially approachable to the ordinary producer or journalist. Podcasts, interviews, documentaries and short features are all being made using immersive audio and large broadcasters like Radio France Internationale (RFI) Radio France, the BBC, Germany's Bayerischer Rundfunk, and others are carrying out research and development work (see Mapping the landscape of immersive audio journalism, below for more).

Research and development tends to be led by audio engineers in collaboration with sound engineering specialists in universities. It is focused on technical issues such as the convincing reproduction of sound (Floros & Tatlas, 2011; Hacıhabiboğlu, De Sena, Cvetkovic, Johnston, & Smith III, 2017; Herre, Hilpert, Kuntz, & Plogsties, 2015) or consumer experience of immersive sound (Francombe, Brookes, Mason, & Woodcock, 2017; Francombe et al., 2018; Lee & Kim, 2013; Melchior et al., 2012; Winslow, 2015; Yao, 2017). Editorial and creative questions fall outside the scope of this work, yet they are of central importance for journalists and producers of narrative factual content who want to use immersive audio.

The field of immersive journalism research could be exploring issues like these but has mainly concentrated on VR and 360 video, where there is of course a dominant visual component, interactivity and lack of linearity, and a very different production chain. There is a gap then, between VR journalism studies and sound engineering R&D, that this research sets out to address.

Aims of the Spatial Audio Journalism project

- Discover the range of immersive audio journalism being made;
- Uncover the issues facing those making that content;
- And to use these insights to inform future creative and editorial (especially journalism studies and radio studies) research and development.

Key findings

1) **VISCERAL AND CINEMATIC.** Though the difference between immersive audio and mono is not as spectacular and the leap from screen media to VR, our interviewees still believed strongly that used well it added 'fairy dust', was more 'cinematic', 'visceral' and 'real'. Using spatialised sound alongside mono also makes it clear that the latter has its own special qualities, allowing the story to occupy a non-naturalistic dimension of sound that is inside-the-head, and therefore intensely intimate, something under-appreciated where mono is simply the default. Mono, stereo and spatial audio formats can form part of a richer palette or sound for audio journalists to work in.
2) **TERMINOLOGY.** There is an overall lack of consensus about whether to use generic terms like 'immersive', 'spatial' and '3D' or refer only to specific formats (eg 5.1 surround, binaural), and a lack of consensus about what generic terms mean. Debates about terminology in VR journalism (Agrawal, Simon, Bech, Bærentsen, & Forchhammer, 2019) are helpful but not enough. Sound is already immersive in different ways to screen media - always diffuse and spatial, never flat (Rueb, 2003). Reference to a specific technical format on the other hand didn't help our interviewees talk about the qualities these technological formats have in common, as more spatialised or immersive, and the way that impacts on storytelling, the construction of a sound scene or the experience of a listener.
3) **DISRUPTION TO THE GRAMMAR OF RADIO.** Audio journalism has longstanding production conventions and listener expectations, and using spatialised sound technology can disrupt as well as complement that radiophonic 'grammar' (an in-depth article by the authors analysing this phenomenon is currently in peer review). Its use forces content producers to think about the placement of interviewees, presenters, and even the listener, in ways that are completely new to those who work in mono and stereo. This does not mean that established conventions are abandoned. The most successful immersive radio pieces adopt a

dynamic approach using mono and spatialised sound flexibly responding to the requirements of the storytelling.

4) **PROFESSIONAL CULTURE**. Sound engineers and trainers often recommend recording equipment and post-production tools with a view to high technical quality and flexibility in re-use of the subsequent recordings, but journalists and producers work in a wide variety of environments that mean they may have different priorities.

   A lot of audio journalists are focused on informational content rather than production values or the storytelling power of sound. They tend not to plan scenes a great deal in advance and to layer sounds in post-production, to give a generalised sense of atmosphere or place. Immersive production requires more thought in advance about the placement of sounds, including presenter, interviewees and the listener themselves – a kind of 'staging' of a scene, which is not common in factual audio – and the development of a spatial sensibility.

   Many work alone and though this may allow freedom to experiment, there is a lack of support when facing practical or editorial issues. Others work as part of a team and have technical specialists on hand from the start. Some work to a daily production cycle, others work on programmes over a period of weeks; some are autonomous and flexible, while others have to make a case each time to use spatial audio in their work; some people work in environments where innovation and creativity are encouraged, others in workplace cultures where speed and accuracy of information are paramount and production values not seen as important. Generally in audio production there is more lone working and consequently a lack of a sense of collective endeavour or community that could help encourage experimentation and excellence in audio journalism.

   The equipment a journalist holds in their hand has an impact on their professional identity and their relationship with those they record. Immersive production can be more visually intrusive (a large multi-channel microphone array, with a sound recordist to hold it) or invisible (in-ear binaural microphones that look like ear buds). The former is a disappointment when you're used to the ease with which people will open up to a microphone, where they might have refused to be filmed. The latter can leave an interviewer feeling professionally naked, without their microphone in hand - the badge of the radio journalist. Ultra-discreet recording equipment also raises issues over privacy and consent, as speaking into a microphone is regarded as tacit consent.

5) **A PROMISING FUTURE.** The equipment and software needed to produce and listen are increasingly accessible and with ever more people listening online, journalism has potentially larger audiences and a far longer shelf-life to justify investment in the production time, training and equipment. Is this a big moment for spatial audio? Most of our interviewees are optimistic it is. However, we find there are some ongoing conceptual, practical and organisational constraints that are still holding journalists back from using spatial audio and using it well. They need time to experiment and learn, including the chance to make mistakes. Changes to budgets over many years mitigate against this, with short production cycles and a reduction in technical support.

These are our recommendations for ways the industry and researchers can support the development of spatial audio in the future.

Recommendations:

1. **Training materials** that help trainers from an audio engineering background tackle editorial and creative questions and help journalists develop a spatial sensibility, foreground the need to plan a scene in advance (as is common in video journalism).
2. **Self-study materials** for individual development, including a library of immersive audio content of different kinds, with an interpretive guide signposting the areas of interest for each (subject to copyright considerations);
3. Sustained **awareness-raising** activities about immersive audio for factual narrative among resource 'gatekeepers' like commissioners and editors as well as journalists and producers. Eg a competition, festival with sound 'screenings' and installations, masterclasses and workshops;
4. Greater opportunities for immersive audio makers to **collaborate and communicate** with each other. This should be independent of various broadcast organisations to allow freedom to experiment and the cross-fertilisation of ideas, outside of changing budgets, market strategies and editorial policy.

To achieve the above, an **international network** or hub should be formed, perhaps through or in partnership with existing organisations like the Radio Academy and Radio Studies Network in the UK.

5. **Audience research** into creative and editorial issues of spatial audio journalism and the ways it differs from mono and conventional stereo, to follow on from this project, which reflects the perspective of producers;
6. **A better-developed vocabulary** to describe placement and the movement of sounds and people in space as well as time (a spatial radiophonic grammar), to help trainers and journalist communicate creative and editorial decisions and techniques;
7. **Experimental research** into more radical potential uses of spatialised sound, including sonification of data, interactive spatial sound;
8. **Transdisciplinarity**: research and development in sound engineering, like object-based audio device orchestration or interactive head-tracked audio, should involve practitioners from journalism or radio studies, or these could conduct follow-on studies, to identify opportunities and problems from journalistic, creative and professional practice perspectives.

Full report

Introduction: Why spatial audio journalism and why now?

Audio is a hugely important medium for journalism globally. Large audiences are still listening to broadcast radio, and increasing numbers are downloading and listening online, with news and documentaries consistently among the most popular output (Mayhew, 2018; Ofcom, 2019; Radio Today, 2019; Winn, 2020). Indeed far from heralding the end of radiophonic journalism, the web has enabled a renaissance in complex factual speech programming, including in-depth investigative series, documentaries and features, and studio-based discussion. The last bastions of high-quality original speech, the public service broadcasters, have found new global audiences and podcasting has opened up the form to new, independent story-tellers and investigative journalists.

The best radiophonic journalism is already utterly engrossing and immersive, even in mono, something sometimes referred to as 'narrative immersion' as opposed to 'technical immersion' (Agrawal et al., 2019; Dominguez, 2017). But there are now new tools to deliver technical immersion or a 360 degree listening experience with a greater sense of three-dimensional space and therefore increasing adoption by features and documentary makers, as mentioned above. There are several factors that make binaural in particular appear ripe for expansion into mainstream use:

- The shift towards online listening around the world (Mayhew, 2018; RAJAR, 2019; Winn, 2020) is starting to free producers up from the constraints of broadcastable formats (though distribution systems can still be incompatible, see 'Distribution and commissioning' below);
- It is hard to get listeners to sit still in the 'sweet spot' of a surround-sound speaker set-up (as it is to get them to sit in the ideal position between stereo speakers!) but people have started listening on headphones in ever larger numbers (Future Source, 2019; Stefani, 2020), and a binaural mix delivers 'surround sound' fairly reliably through headphones;
- Small, discreet, in-ear binaural microphones can be bought cheaply now and the recordings can be edited in the same way as conventional stereo;

- There is software to create a 3D sound picture in post-production, from multiple sources, which can be used to produce a binaural headphone mix or other multi-speaker surround sound mixes. Though these require more specialist skills than binaural capture, many working in the media have a greater familiarity with media technology than they did in the 1970s and 80s (when early experimentation took place, see Mapping the landscape below) as a result of the rise of multi-skilling and people's familiarity with media production tools on every home computer and mobile phone;
- Immersive audio has a role in cinema and gaming (Melchior et al., 2012) and the development of immersive journalism for VR and 360 video has raised the profile of immersion generally, encouraging the funding of R&D.

There is a range of content being made (again, see below). This stage in the development of immersive audio is significant, because it marks a move to mainstream use for a popular general audience, distinct from its more experimental uses, which include soundscape recordings and art installations, as well as early, more gimmicky applications, like ASMR recordings or the famous 'Virtual Barber Shop' which can be heard on YouTube (https://www.youtube.com/watch?v=IUDTlvagjJA).

What other research is taking place?

Some major broadcasters are investing in research and development in immersive audio. Radio France created a division devoted to immersive audio, called Nouv0son, in 2013 (Dussert, 2019) and audiences can find immersive audio productions on a dedicated website, Hyperradio. The BBC's R&D division has conducted research over several years and, together with Radio France, Germany's Bayerischer Rundfunk, Radio France Internationale (RFI) and others, is part of a major project to develop a flexible system for delivering spatialised sound[1] to consumers through the development of systems for object-based audio which can adapt to listeners' particular listening devices. The field of audio engineering research is also engaged with very specialised issues to do with the accurate reproduction of sound (Floros & Tatlas, 2011; Hacıhabiboğlu et al., 2017; Herre et al., 2015), user perception or experience of specific immersive technological developments (Francombe et al., 2017; Francombe et al., 2018; Lee & Kim, 2013; Melchior et al., 2012;

[1] https://www.orpheus-audio.eu/

Vinton et al., 2017; Winslow, 2015; Yao, 2017). There is a general orientation towards immersive audio as a technological problem to be solved, in order to serve a consumer market. Editorial and creative questions are not in the remit of audio engineering (Though some, like Agrawal et al. 2019 have interrogated concepts such as 'immersion' or 'presence').

Sound art and soundscape composition (Batchelor, 2019; Licht, 2007; Licht, 2019; Westerkamp, 1989) and film sound (Chion, 1994; Chion, 1999; Kerins, 2011) have some relevance when it comes to craft or creative techniques of immersive sound. Making linear narrative factual content introduces some different problems to the capturing of soundscapes, non-linear sound installations, or the special combination of vision and sound that film sound design works with.

There has been plenty of work on immersive journalism in recent years (Mabrook & Singer, 2019; Watson, 2017) and it does engage with the creative and editorial implications of immersive media technologies. There has been practical experimentation with immersive storytelling and user responses to it (de la Peña et al., 2010; Mills, Pellanda, & Pase, 2017; Newton & Soukoup, 2016; Owen, Pitt, Aronson-Rath, & Milward, 2015; Pavlik, 2003; Pavlik & Bridges, 2013; Sundar, Kang, & Oprean, 2017) and analysis of immersive content (Dominguez, 2017; Jones, 2017; Koski, 2015).

Immersive journalism allows people to experience events or situations normally described in a news report, 'entering' a story or being 'transported' and returning afterwards, changed (Alzamora & Lorena Tárcia, 2012; Chainon & Chainon, 2018; de la Peña et al., 2010; Dominguez, 2017). There is a frequent assumption that a strong sense of 'being there' and an illusion of non-mediation or the breaking of the fourth wall represent successful use of immersive technology (Bracken & Skalski, 2010; Dominguez, 2017), and these ideas have been explored in the literature on telepresence.

As a result, it is often believed, the user can more richly experience other people's lives and far-away places, and immersion is often assumed to be especially powerful for eliciting empathy and other emotions (Burgess, 2017; de la Peña et al., 2010; de la Peña, 2016; Elmezeny et al., 2018; Owen et al., 2015; Van Damme et al., 2019). For this reason it is also felt to help engage hard-to-reach or distracted audiences in an age of information overload and compassion fatigue (Jones, 2017; Koski, 2015; Pavlik & Bridges, 2013).

Immersion is associated with a spatially more real, three-dimensional storyworld that is bodily inhabited, rather than viewed on a flat and distancing screen. The development has led to a subtle shift in conceptualising stories, whereby it has become possible to talk about 'spatial narratives' (Dominguez, 2017) and a kind of reification of the news story,

which a person can 'enter' and move around in, returning afterwards, changed (Alzamora & Lorena Tárcia, 2012; Chainon & Chainon, 2018; de la Peña et al., 2010; Dominguez, 2017). This leads many journalists to think of the audience differently: as individual witnesses to the events (Chainon & Chainon, 2018; Doyle, Gelman, & Gill, 2016; Koski, 2015; Mills et al., 2017; Owen et al., 2015) or as 'detectives' investigating or following their sense of curiosity (Newton & Soukoup, 2016).

The spatialisation of narrative and interactivity all introduce new complexities to journalistic norms and practices (Mabrook & Singer, 2019). Techniques for montage, camera angles and framing, graphics and text, in vision reporting, and voice-over narration are no longer deemed desirable, because they destroy the illusion of an unmediated environment, the sense of 'being there' (Dominguez, 2017; Elmezeny et al., 2018; Healy, 2018; Murray, 2016; Owen et al., 2015). Revisiting the conventions of audio-visual editing and the visual perspective of the audience is deeply disruptive because these aspects of TV grammar play a role in establishing journalistic authority through the performance of objectivity and impartiality (Tuchman, 1972; Tuchman, 1973; Tuchman, 1978).

But in all this literature 'immersive journalism' is invariably understood to mean virtual reality and 360 video. These formats are different because they tend to be interactive and non-linear, VR is produced using very different, highly specialised tools and of course both are dominated by the visual. The shift from mono or stereo to immersive sound is less of a stretch than from a flat screen to VR, radio never had a fourth wall to lose, and has always been to some degree immersive, or at least rather diffuse or enveloping (Rueb, 2003). Speech radio and podcasting (which we term 'radiophonic speech') have their own production patterns and grammar which naturally differ from TV and film. So before we can inform and support the use of spatial audio for radiophonic journalism we first need to establish what the key issues are in terms of its value and use, creative and narrative techniques and organisational infrastructure and professional cultures.

Project methodology

This research was carried out by researchers in Journalism at Falmouth University and the University of Brighton's School of Media between June 2019 and June 2020. Its aim was to open up future research into the editorial, creative and professional cultures aspects of immersive audio. The researchers have a background in sound design, sound art, and radio programme-making in the UK and Germany, and started from the perspective not of immersive audio technology experts, but as content makers.

The research has two parts:

1. **A web-based audit of immersive audio journalism**, in which we include all factual narrative content for a mass audience. In other words speech radio and podcasts including documentaries and features but excluding art works and installations, coverage of music concerts and live events without commentary or discussion.

   We collated as many examples of immersive factual audio as we could find through a web and podcast app search and added any additional examples mentioned by our interviewees. We searched using the terms 'binaural', '3D', 'immersive', 'spatial', 'surround sound', 5.1, 'quad' and 'quadraphonic'. We also searched using terms in German and French and Dutch, eg 'son spatialisé', 'immersion sonore', 'Mehrkanal-', '3D-geluid' and so on. We included the web and other promotional texts associated with the programmes, for insights into the way they talked about immersive audio, and any patterns in the descriptions of content and listener experience.

2. **Interviews with producers of immersive audio journalism**. We approached all named producers and reporters we could find during that audit, and any colleagues suggested to us by those interviewees, asking for a Skype or phone interview. Over the summer of 2019 we interviewed 18 people who responded and were available. They included independent producers and those working at big broadcasters BBC, Al Jazeera, NPR, RFI and Radio France. Most were in the UK and France, others in the USA, Qatar, South Africa and Australia.

   We used our own experience in production and the insights coming out of the field of VR immersive journalism, radio and film studies to develop some open-ended interview questions that would allow interviewees to direct us to the issues that were of concern to them. We asked them about the process of production in immersive audio from planning to mixing, about things that worked well and less well, and infrastructural issues that supported or impeded this work. Finally we asked if they had any blue sky ideas for the technology that no one had yet tried.

The next section offers a thematic overview of the results of this research and some suggestions for future research. More concrete recommendations are to be found at the end of the executive summary above.

Analysis

Mapping the landscape of immersive audio journalism

Immersive audio, as is so often the case with a new technology, goes back much further than you would expect: 1881 in the case of binaural recording (Pike, 2019). It wasn't used in the nascent development of radiophonic journalism in the first half of the twentieth century (Black, 2010; Crook, 1998; Douglas, 2004; Hendy, 2007). In the 1970s and early 80s some binaural audio drama and features were produced in Germany (Krebs, 2017) and binaural and quadrophonic programmes at the BBC (details of which can be found by searching the BBC Genome website). Radio France produced some work in the 1990s in Dolby Surround. However in this first wave of production, recording was a fairly specialist affair, using binaural dummy heads or special multi-microphone arrays.

Speech programmes were also synonymous with broadcast radio, and although FM can transmit binaural stereo other formats cannot be broadcast and until the rise of the smartphone, it was all being listened to on single-speaker radios by anyone other than committed audiophiles, who might be willing to sit in the sweet spot of a surround sound system. Interest in immersive audio bubbled along below the surface, but there was something of a loss of confidence about its relevance among mainstream audio producers (Roginska, 2018).

Our contemporary revival seems to begin with a few isolated examples around the mid 2000s as computer and smartphone listening were taking off. Some entire series were commissioned in France and the UK in 2013 and then a greater number of programmes and items within programmes were produced from 2016 onwards.

It's worth noting that a web-based audit like this is largely limited to programmes which are online and subject to Google search ranking algorithms, though a small number of programmes were suggested by interviewees. Even in the revival phase, where content was being delivered online, programme pages can be taken down. We discovered reference to two programmes recorded in quadraphonic sound for NPR in 2004, but when we contacted the producer he told us it was originally a series of 5 programmes. The web search will also only have pulled up examples which were accompanied by a web text

including one of our key terms. One of our interviewees told us some BBC journalists have used binaural capture as part of radio news packages, without flagging up the information on air or on a programme page and they had no more information.

The audit can't give us reliable quantitative data then, but we can get some sense of the breadth of uses immersive audio is being put to, and the kinds of output covered. There is a wide range from studio discussions and conversational podcasts, through documentary features and investigative podcasts, to programmes that combine factual content and semi-fictive recreations. As we mention above, some news reporting has used binaural capture too. Subject matter is very varied and includes topical and serious issues as well as impressionistic audio snapshots of places and people.

Though news packages and studio discussion in immersive formats exist, the greatest concentration of activity was in the area of creative features. By this we mean documentaries and short features, following montage format, that is, not structured by scripted narration or 'links'. Many of these are featured in arts and culture strands, or broadcast on networks associated with arts and culture output such as BBC Radio 3 and France Culture.

From our knowledge of working in radio, from reading accounts of VR journalism and given what our interviewees are telling us, there seem to be four reasons for this:

1. Immersive output can be slightly slower and may even be a great deal slower and more labour-intensive to produce, and departments which already work with slower production cycles are better able to integrate it into their existing work patterns.
2. A new technique requires a willingness to experiment and some risk producers won't achieve the desired results. Arts and culture channels, programming strands and departments are already invested in experimentation and report on the experimental and risk-taking work of artists in other spheres.
3. Awareness of the technological tools and ability to use them is not widespread, and many of the programme-makers using them have a background of some kind in sound engineering or a technical role in production. They often also have a background or interest in sound engineering for sound art and for music and produce music programmes, drama and art installations (not included in our audit, because of our focus on factual content). There is a likely link however between this creative experimentation and the number of factual programmes about art and music and which interweave fact and fiction.

4. Immersion, narrative as well as technical, is closely associated (according to the immersive journalism literature, our interviews and programme texts) with allowing audiences to be transported to different places, to feel different experiences. In other words it is associated with sensation more than information. This kind of atmospheric and creative sound is already associated with the long-standing tradition of radiophonic features or radio pictures (Crook, 1998; Hendy, 2010; Madsen, 2010; Scannell & Cardiff, 1991, p. 117), which are expressionistic, capture sense of place and are not expected to deliver a tightly narrated and structured narrative, deal with topical issues or introduce debate and balance, though they may do so.

Immersive audio is still sometimes used in a slightly self-conscious way in the programmes we found, perhaps explained to listeners in the web text or by an announcer. Some work fills the 360 space with sound and movement as if to maximise its potential or justify its use, much like cinema sound 40 years ago, according to the film sound designer, Michel Chion (2010). To work in immersive audio is to ask for more resources, which includes slightly longer production time, perhaps the support of a sound recordist or a large microphone array, and it means having to develop new skills, and for all these reasons it means taking a risk. No wonder people feel the need to make it stand out as a spatial experience. But to find its maturity, immersive audio needs to move beyond the most obvious or 'extreme' uses, to become part of the audio producer's repertoire of skills.

Terminology

The concept of immersion is complex and sometimes used in confusing ways (Agrawal, 2019). There is a range of terms in use, and no general consensus about the differences between them. Broadly, we can distinguish between terms for technical systems (eg. Binaural, ambisonic, 5.1 surround) and terms that aim to capture the way the listener experiences the sound (3D, spatial, immersive).

One common theme from our interviews is that people are using different terms to address colleagues and audiences. For example, one producer uses 'spatial' and 'immersive' to talk to audiences, because these words describe the effect of the technology clearly on the listener. The same producer found though that when talking to other professionals, they couldn't agree about what these words meant, and they seemed imprecise. This producer, like others, preferred to specify the technology they were using, for example talking about whether to use an ambisonics microphone, or producing a binaural mix. This means that among themselves, professionals are choosing terms that

sidestep discussions about the feelings evoked by these tools or the impact of spatialising a scene on the editorial or narrative process.

Even when our interviewees tried to use terms precisely, to describe technical differences, they didn't agree which words should be reserved for which category of audio. So some said 'surround sound' was for speaker set-ups only, while another said that was '3D sound'. One felt 'spatial audio' was reserved for object-based audio, while others used the term spatial as a generic term for anything offering more space than stereo.

These are the most commonly used terms however:

Immersive. This one seems to be problematic for a lot of people, in that it describes a sense of being involved, engrossed in a story, and as several people pointed out, stereo, mono and even the written word on a page, could all be immersive. For that reason some of our interviewees chose not to use it and others used it with care. It was thought to have good recognition by the general public though, because of the awareness of VR and 360 video. That was another reason for caution in its use for some though, because the usual radiophonic experience is linear and non-interactive, while VR immersion is associated with interactivity. One interviewee felt audio needed to make its own mark, and not be confused with audio-visual media.

3D is used in France a fair amount when it comes to audience-facing materials, but some UK interviewees had been told to steer away from it, because of its association with 3D TV, which was seen as a failed experiment or fad. However, for some interviewees the words 3D or three dimensional were appropriate to draw attention to what was significant about this kind of sound, both for listeners and when it came to capturing and mixing sound. Firstly, '3D' has good recognition as a concept with the general public. Secondly, it seems to refer to the sense of solidness, or realism of the sounds, and thirdly, it can refer to the 360 sound picture around a '3D' microphone, which translates to a three-dimensional sound environment for the listener. One of our interviewees however, reserved the word 3D to describe ambisonics microphones but not binaural capture.

The term **spatial** audio is very clear and descriptive, has none of the baggage of 3D or the confusion of immersive. One interviewee valued it for the fact it draws attention to the need to consider the space of the story, as well as the way it unfolds over time. However for some people it has an association with sound engineering research and feels a bit specialised. One of our interviewees thought it normally referred to speaker arrays not headphone listening, and so for them it was less useful as a general term, and as mentioned above another associated it with object-based audio. However people often turned to 'spatial' when they wanted to describing the sense of space and the way that

these formats were 'bigger' and '*more* spatial' in terms of acoustics and information about the setting of the scene.

So in summary, it would be helpful if there was a clearer shared vocabulary to describe the common effects or qualities of these audio technologies. It could facilitate sharing of techniques and craft skills (something several interviewees wanted more of) and awareness-raising about the value of audio immersion. But at the moment choice of words seems to be particular to the individual and open to misinterpretation.

The significance of recording equipment in everyday production

Much work is being captured using spatial audio technology of some kind, with some work also being binauralised or spatialised in post production. The latter is used for documentaries and longer creative projects, and requires specialist software and a high level of technical knowledge, but it does leave the producers with a greater range of options. Those producers we interviewed who were also trained as sound engineers or sound designers were confident using these post-production tools and fussy about the technology and techniques they used to achieve the effects they wanted.

If the audio is captured in binaural it cannot be changed a great deal in post-production, so any issues with spatialisation cannot be corrected, for example if an edit makes it seem an interviewee jumps from one position to another, or two people are too close together to easily distinguish their voices. Binaural seemed to be the most common format however, probably because it is easy to learn and cost-efficient.

At the BBC, some people have also been using a binaural 'dummy head' arrangement for documentary making and studio-based work. At Radio France, recording is normally done with a mic array (a set of microphone capsules that capture several separate sound channels) allowing them to mix in 5.1 for speakers and binaural for headphones. Because of this, a sound recordist has to support the recording and post-production stages, which places it out of reach of news teams.

The choice of recording equipment is a practical concern, but it also affects the relationship between journalists and their interviewees. High quality directional microphone arrays can be cumbersome and are also extremely expensive. The requirement for more technical understanding of directional audio capture means that recording needs a level of planning and set-up that conflicts with journalistic immediacy and involves attending a scene with a team of people, while radio journalists are used to a more low-key and direct relationship with their interviewees.

It is felt to be easier to get someone to agree to speak for radio than television, and the mono microphone is small and unobtrusive. A dummy head or a large mic array are very obtrusive and can distract an interviewee, make them more self-conscious or even unwilling to participate, and therefore less attractive to those working in news and current affairs or on sensitive documentary subjects.

In-ear microphones are the opposite of this. They are even more lightweight, portable and discreet than traditional reporter microphones and can integrate with mobile phone recording systems. Their very discretion means journalists need to consider the issue of consent when they record on location. Interestingly, some users suggested they felt less professional when wearing these instead of carrying a microphone in their hand, which normally operates as a kind of official badge of their trade.

Telling stories in space as well as over time

Audio journalists and documentary makers are used to thinking about proximity of voices and sounds to the microphone, the size and acoustic qualities of the space they record in, and in a conventional stereo recording voices and sounds can be front and centre, slightly to the right or slightly to the left. Using a spatial format opens up a much wider space to play with but also introduce a much greater degree of precision with regards to placement. Features making in mono or stereo involves a layering of sound to produce a generalised sense of atmospheric richness, while spatialised formats allow the human brain to discern more precisely where a sound is in space. All our interviewees said they had learnt this means more careful thought needs to be given to where people and things are in the sound scene and that decisions may need to be consistent throughout the scene, so as not to confuse the listener.

Perhaps the most challenging person to place is the listener, who is always external to a sound scene in mono and stereo, but is internal to the scene in spatial audio (hence the use of the term immersive). When capturing or structuring an audio scene the producer needs to decide if they want the listener to be listening from the perspective of one of the presenter/reporter, next to them as a companion, or if they will occupy another perspective point.

Our interviewees had either made mistakes or knew stories of other people's mistakes, such as placing dummy heads or other binaural mics in the centre of a recording so they capture the sound well. Of course in a mono or stereo picture this would give clear audio, but in immersive formats, it places a listener in that central position, with people speaking

around them. This was felt to be unnatural or uncomfortable for the listener, who clearly would not normally sit in the centre of a discussion table. And because binaural audio is fixed or head locked, any sudden noises from the side or behind can shatter the illusion of immersion in a scene, as the listener turns to hear more, but the sound scene also turns with them.

If a reporter wore in-ear binaural microphones, but also spoke during the recording, some of our interviewees felt this could sound a little 'odd', as the listener was being offered a kind of first-person experience, which was undermined by hearing the voice of another.

Despite the problems in placing a listener, our interviewees were clear that when it worked well, it was precisely the sense of being transported, being at the heart of an event, that made spatial audio special.

We asked our interviewees about the kinds of story or situation that are most and least suited to spatial audio formats. Not surprisingly particularly special and atmospheric settings were seen as most well suited, especially where there is a lot of movement or where the space is an important component of the story. Also exotic and hard to visit locations were seen as ideal, such as deep in a cave system or travelling to a rain forest. Like in VR journalism (Dominguez 2017; Burgess, 2017; Chainon and Chainon, 2018; Van Damme et al 2019). A lot of our interviewees saw immersive audio as having great potential to help listeners understand what it feels like to experience someone else's reality, and therefore better understand them or their stories.

Though scenes without movement were seen as not usually worth the spatial treatment, movement itself can be problematic. Moving the microphone through a sound scene that itself also involved movement led to a muddling of the geography of a scene in a listener's head. Some productions made effective use of very static scenes that were nonetheless spatialised. One advantage of spatial formats is they help listeners distinguish between sounds, as they can in real life. Therefore it is possible to record an interview in a noisy environment like next to a coffee machine or at a music event, and the listener should be able to hear the speech above the ambient sound.

Binaural recording was popular with our interviewees for atmospheres and soundscapes which were described as more real, bigger, more vivid and immersive. Where binaural was used for voices, it could sound 'mushy' or indistinct and slightly too far away however, so some of the producers with the most experience of spatial audio had taken to recording interviewees separately with a close, mono microphone. Moving from binaural to mono was described as 'zooming in' in this case.

Even more than zooming in close, when listening on headphones especially, mono and stereo sound is experienced as *inside* the head of the listener (a phenomenon known as inside-the-head localisation), while binaural sound seems *outside* the head. This has led to some new appreciation of the special qualities of mono and stereo sound and means that a spatial production operates not only in 360 degrees round the listener, and on an axis of far to near, but of interior and exterior sound, placed or placeless. These additional non-naturalistic dimensions of space (interior and placeless) have no parallel in visual media. The range of possibilities can present problems in the edit. While cutting together mono recordings is easy, editing binaural recordings can lead to jump cuts, as voices move in space.

Despite these complications, productions can make use of binaural (or other spatial format) together with mono and conventional stereo sounds within the conventions of radiophonic speech, with some care over scene planning. Learning to weave them together is something that could be learnt by trial and error. It means that some of the conventions of audio journalism storytelling like narration and cutting can be absorbed easily into spatial audio production, unlike VR storytelling, where traditional TV techniques like these are seen as irrelevant or may break the sense of immersion (Dominguez, 2017; Koski, 2015; Murray, 2016; Watson, 2017).

Looking to the future: how can we support journalists to use spatial audio?

We asked out interviewees what measures would help develop the capacity of programme-makers and journalists and facilitate the more widespread adoption of spatial audio.

Their answers fall into the following areas:

Just do it

As spatial audio becomes mainstream and is used in different genres and for different content, its use raises new questions and problems that will only resolve themselves with increased use and familiarity. Therefore there was a belief that the best way to encourage good spatial audio production is to get more people using it, more of the time, learning as they go. This would also benefit the wider production community, if knowledge is shared, as at the moment many of our interviewees felt they had little or no opportunity to talk to others about working with spatial audio.

Most felt they had learnt from trial and error, which means having the freedom to 'fail' in an immersive audio experiment, but having a plan B, such as a mono recording made at the same time as a binaural capture.

Sharing, training and community

Although it was felt to be important that people should be allowed to experiment and be creative, as the form was still developing, completely uninformed experimentation is likely to be off-putting. The chance to try out something new (which might not work) implies more time to think and plan than some journalists get, when production cycles are short, teams are smaller, and people are covering more stories each than they used to. Training designed around their usual production practices and the genres of content they make would help give them confidence to try immersive audio, and to plan a recording effectively to avoid basic problems.

Some people working for large broadcasters have access to training, one-to-one planning support and online guides to choosing microphones or setting up a recording. Where training and guide materials exist they focus on practical instructions on recording and

editing tools and how to operate them correctly. Interviewees were clear this was important, but in itself insufficient.

As we discussed what our interviewees had learnt through trial and error, it seems it would be useful to develop training that helps programme makers develop a spatial awareness, thinking of a spatialised sound scene that must to some extent be planned, for example positioning different interviewees, the presenter and the listener. This was described well as a 'spatial sensibility'.

There is a desire for more informal sharing of ideas and knowledge too. Our interviewees often wanted to know how others had replied to a question or what we thought. Several mentioned that audio production tends to be a lone endeavour, which means little chance to discuss techniques or ask for help when trying out a new technique such as spatial audio.

Several interviewees suggested people need to listen widely to spatial audio content, to slowly gain a feel for what it is and how it works in practice, as well as in theory, to raise their awareness of space as an element of telling stories in sound, the 'spatial sensibility' already mentioned.

Establish new habits and workflows

Journalists and other kinds of programme maker have routines and habitual ways of working. They carry certain kit, and use it in a certain way to produce material to familiar formats. As the formats don't have to change in spatial audio, unlike VR journalism, simply adding or swapping in spatial audio kit – for example a pair of in-ear binaural mics or an ambisonics mic – can help them develop new 'immersive habits'.

This could produce a step change in spatial audio production by giving journalists tacit permission to work this way, and breaking mono or stereo habits as the default.

Though there may be kit available in organisatiotn, most journalists working for big media companies lack spatial audio tools as standard, having to request them as an exceptional case. People at RFI, Radio France and the BBC suggested everyone should have the equipment and editing tools at each desk, so they don't have to ask for them. If they are the same or at least compatible, it means people develop habits and skills, and can also share material and work together on projects, which makes it more feasible to use spatial audio, given how much content is shared and repurposed these days in the interests of efficiency.

Some interviewees expressed doubts that spatial audio production will flourish or even survive long term if it does not become habitual and integrated into everyday production.

However, there is no one-size-fits-all solution to spatial audio and so the choice of what techniques and tools to invest in is a difficult one. The BBC is offering several with guidance on the pros and cons of each. For large media organisations that produce a wide range of programming including drama, music, outside broadcasts and news and current affairs, it makes sense to keep options open. But the lack of consistency of tools available and workflow prevents producers from quickly developing a set of shared, generic immersive audio skills.

Culture change

It's not only practical changes. A culture shift might be needed in some places, if immersive audio is to be adopted, according to our interviewees. High quality audio production is threatened by the predominance of journalism as information (written and spoken words) and the visual bias of our media culture, particularly on the web and social media, where text is the main means of finding and navigating content and video may be uploaded to social media platforms like Twitter, Facebook or TikTok, but not audio.

Different countries have different traditions in terms of genre and programme format that affect the adoption of spatial audio. France seems to have a more marked distinction between news and other factual output, the one is 'hot' or extremely topical and produced quickly by individual journalists, while the other is 'cold' or not topical and produced by documentary teams over a number of weeks. News teams not only work in different ways (usually alone) but have different training and different values when it comes to output. Content takes precedence over production values and content is conceived of as information, conveyed through words. Journalists may be recruited from a print background and trained to value speed and accuracy. They are unlikely to consider the non-verbal meaning that can be communicated through a sound scene, and lack an awareness of the longstanding codes or grammar of radiophonic programmes and podcasts, codes that their audience on the other hand may understand well.

In the UK the BBC produces news and current affairs, and specialist topical 'magazine' programmes, which combine straight speech (studio presenters, live interviews, reporters reading scripted stories and so on) with mixed features and packages, which may include atmospheres, music and effects. Therefore reporters and correspondents are well versed in radiophonic production values.

There is always substantial pressure on audio production however and in France, the US and Britain interviewees described a move in the last twenty years to an ever-faster 24-hour, multimedia news cycle, where numbers of specialist producers and technicians fell and journalists were discouraged from spending time and money on crafted sound in many places. The BBC has announced it is no longer recruiting specialist radio reporters (Thorpe, 2020) a move away from specialist audio production to multiskilling that could work against the wider adoption of spatial audio. Al Jazeera's radio network Jetty uses audio gathered by its multimedia reporters who prioritise the visual. It seems that the cultural dominance of the visual means that where cuts are made, even though audio production is far cheaper, it is always audio production that suffers. And of course the coronavirus pandemic has meant a great increase in the amount of content recorded remotely via web video link or mobile phone. Though this happened after the research was complete, it can only be assumed the roll-out of spatial audio journalism has come to a standstill.

Routinely producing high quality immersive audio increases production costs, and increases the data burden for audiences, arguments our interviewees had heard against its uptake, but they were not convinced. Video is a far greater data burden, yet in our visually dominated media landscape, more and more outlets were producing HD video for audiences.

In France and the UK it is felt that podcasting and on-demand listening means good quality journalism has a longer shelf-life, was no longer 'ephemeral' or 'throw-away', which could change priorities at large media companies. Additionally, as more people are listening on headphones, rough and ready editing is more noticeable, and more crafted and radiophonically interesting sound has a larger and more attentive audience. Though interviewed before the pandemic, our expert interviewees felt that journalists are expert storytellers, and keen to learn new ways to engage audiences. In recent years they have learnt multimedia web storytelling, using Snapchat and TikTok, and the far more technically demanding and expensive VR, and are producing HD video news as routine in many places. So it seems fair to say that journalists can expand their repertoire to include immersive audio, if they can see its benefits and have the right institutional support from planning, through production to distribution.

Distribution and commissioning

Interviewees told us commissioners, controllers and other senior people in audio commissioning in the UK and France value immersive audio content because they think it will attract listeners. There was some concern that they might not be very committed long-term if they are valuing it for novelty.

Senior staff might also lack some necessary understanding of the practical realities of immersive audio production and distribution. For example some interviewees had been asked to make immersive audio content without the extra production time needed. Giving binaural production tools to journalists, without giving them the time to try them out, leads them to simply resist using the new technology, reinforcing the idea they are not interested in production values or are resistant to change.

The BBC World Service commissioned a binaural documentary, only for the producer to discover at delivery that the station's podcast channel was mono. Other BBC and RFI interviewees recalled networks had commissioned binaural content without taking account of automatic compression which applied before FM transmission or web streaming, which destroyed the spatial effect. Distribution channels that don't compress the audio are needed for the delivery of immersive sound, and these don't need to be visibly differentiated from the listener's perspective. To make this happen, better communication is needed between different specialisms: programme makers, audio engineers and commissioning and senior editorial staff.

The added value of spatial audio

The report so far has raised problems and needs – which is what the research set out to do –but these are worth overcoming. Generally speaking our interviewees were very positive about the value that spatial audio can bring to all forms of factual audio production, from news to documentary features and podcasts. Some of the perceived positive qualities of immersive audio are familiar to anyone who has read about VR journalism – that it transports audiences to somewhere special, that it's magical experience, that it can encourage empathy. Some are a little more surprising. For example, several interviewees described it as more **spacious and comfortable**.

People commonly described binaural in particular as elevating journalism and documentary making with a **more real** or realistic sound, even '**hyper-real**'. Others used the term '**natural**'. In comparison, conventional stereo was sometimes referred to as 'fake'.

They describe an increased sense of perspective and movement too, which are more '**sharply defined**', and '**vivid**', or '**a sensory hijack**' at low cost.

That it **transports** the listener to another place is another common claim - especially somewhere they can't go in real life, such as among a flock of butterflies, in the Amazon rainforest or inside a factory or tunnel, the site of a humanitarian crisis such as a warzone. The experience of this transportation is described using words like '**visceral**' and '**immersive'** and providing 'a compelling sense of place'.

The idea that immersive audio is **more compelling** or commands more attentive listening came up a few times and some more experienced producers believed the effect could be enhanced by judicious use of, say binaural, in short bursts, with mono or conventional stereo in between, so that each time it '**grabs the attention afresh**'. Sometimes our interviewees spoke of immersive audio as a way of almost tricking the listener into learning facts or hearing experiences they would otherwise switch off from – mentally or in a literal sense hitting the stop button.

As with VR journalism, it is sometimes hoped that transporting the audience in this way with immersive audio will encourage **empathy** and is a tool for journalists to fulfil their perceived remit to get audiences to 'connect' with stories and with people, especially those in other parts of the world or with perspectives and experiences not often centred in the news. Terms people use to describe the nature of that connection include '**first person perspective**' and being put 'in the shoes of other people.'

Some interviewees in the UK and France felt both the spatial information and the enhanced empathy might help the work of journalists in combating polarisation, by allowing different audience members to see things from each other's perspectives. Some people mentioned coverage of Brexit and the Gilets Jaunes movement, and parliamentary or other political debate.

Often immersive audio is just felt to be bigger and better technically. We heard it referred to as '**cinematic'**, a '**fuller, sexier sound'**, and '**fairy dust'**. This is more than just spaciousness in the sense of comfortable listening and letting sources 'breathe', but implies more dramatic storytelling. While mono is 'very small' with spatial sound 'the world suddenly opened up'

It should be borne in mind that these feelings about the value of immersive sound are from the perspective of these journalists and sound engineers who might not be representative of a wider public. There is no listener research that we are aware of that tests these claims for the value of immersive audio for journalism.

Some radical ideas

Most of the uses of spatial audio are within conventional radio formats, but before training and development succeed in routinising its use it is worth recording some of the more avant-garde ideas our interviewees came up with.

Where radio conventions mean music is lowered in volume 'beneath' the voices of interviewees and presenters, it is possible to move it behind instead, as the listener is better able to distinguish sounds in a spatial mix. So the grammar of mixing could be impacted by wider use of immersive sound.

It could also be used for spatialised data sonification, especially if plans to deliver object-based audio to any household's individual speaker set up comes to pass and broadcasters can orchestrate spatial sound coming out of different speakers round someone's home, enabling, for example, election results to be communicated in one part of the sound scene, and analysis and discussion in another.

Spatialised mixing can also change the relative size of objects in sound, which some people were keen to explore, perhaps to show the relative importance of ideas or events in a non-naturalistic way.

Finally, though at the moment spatial audio for narrative journalism like this is linear and non-interactive, head-tracked sound could make interaction with the sound scenes possible in the near future.

Conclusion and future directions for research

This exploratory research into an under-developed field of journalism and radio studies has successfully established the range of factual content being produced using binaural and other spatial audio formats. We argue this is an opportune moment to broaden access to spatial audio production. We have also identified some issues that need to be given more attention in order to expand the use of these technologies and encourage ambition in the field of audio journalism.

Lots of exciting and high quality work is being produced by people who are working in relative isolation from each other. We would like this report, journal article and our blog to lead to the development of resources for audio journalists and documentary makers, as

well as the managers, commissioners, trainers and sound engineers who support them, to play a role in promoting continued innovation in the field of radiophonic journalism.

Our research shows immersive audio offers some important added value to radiophonic journalism, offering richer, more real or vivid sound scenes that feel immersive, a larger or 'cinematic' kind of sound, a three-dimensional sense of space with more precise differentiation between parts of the sound scene and – something we didn't expect to find – a new awareness of the wonderful qualities of mono sound. Mono, stereo and spatialised sound can in combination offer a richer palette for programme makers.

Unlike VR, spatial audio fits almost seamlessly into existing formats if it is used for enhanced ambient sound in a package or feature. Recording 3D atmos with an ambisonic mic or in-ear binaural mics in this way might not even present much of a challenge to standard routines and ways of working, where radiophonic production values are already high. Of course in many production teams, even recording atmosphere and actuality (meaning the sound of events in progress) is not the norm and as some interviewees have argued, this is an issue that requires addressing separately. Since we began the project, coronavirus has reduced the amount of location recording further, and placed additional budgetary pressures on many media organisations. While we want to encourage media organisations to place greater value on telling stories in high quality sound, these changes work against that, and towards the prioritisation of information over sound.

We conclude that using immersive audio does necessitate some changes to working practices. Features making tends to layer sound for a general sense of space or place, but immersive audio is more precisely spatial, and the listener has a place in the sound scene. This means journalists must plan the staging of a sound recorded scene, rather as a video journalist would.

This newly spatialised sound scene can be vivid and compelling and could also provide a new dimension to use symbolically, as some of our interviewees proposed, for example to communicate relative position or importance of ideas, people or objects.

Realistically, to encourage more journalists to introduce spatial audio to their repertoire, we need to ensure they have time and space to try things out and make mistakes, and a culture of acceptance of ambition and experimentation with sound and new technology. Not everyone works in such supportive environments. Even taking out a pair of in-ear mics on a story might seem silly or needlessly complicated, when no one else in your department is doing it. But all the people we interviewed who have produced successful immersive audio have taken the risk to experiment in precisely this way, and learnt through trial and error.

Future research:

The most pressing need seems to be for audience research. Existing user testing tends to focus on comfort, usability and technical issues, and the results are sometimes not available outside the organisation that conducts the research. The researcher and our interviewees have therefore had to rely on our own interpretation of material produced in spatial audio, making the observation that a particular technique is, for example, 'cinematic', 'realistic' or 'confusing'.

Research with a wider range of listeners who enjoy narrative audio journalism already could better establish the range of responses to different techniques mentioned here.

Though we have established a need for enhanced training and development opportunities that deal specifically with creative and editorial issues, we also suggest some workshops and online materials could be tested with producers and journalists and their feedback collected. The results of this could help future trainers plan better training in spatial audio for programme makers.

For our specific **recommendations** see the end of the Executive summary

If you want to read more, in addition to this report, which summarises the project as a whole, there are three further outputs in development:

1) A journal article examining the way space is used in spatial audio journalism to distinguish between different kinds of contributor to a story;
2) A journal article critiquing the concept of 'immersion' in radio and podcasting;
3) Workshops and workshop materials for audio producers, to be developed at workshops in the summer of 2020, which have been postponed because of coronavirus.

Details of all outputs will be updated on the project blog:
https://spatialaudiojournalism.home.blog/

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